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Original Article - Voiding Dysfunction

Prostate Volume Measurement by Transrectal Ultrasonography: Comparison of Height Obtained by Use of Transaxial and Midsagittal Scanning

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Purpose: The purpose of this study was to compare prostate volume measured by transrectal ultrasonography (TRUS) between transaxial scanning and midsagittal scanning. We tried to determine which method is superior.

Materials and Methods: A total of 968 patients who underwent TRUS for diagnosis of any diseases related to the prostate were included in this study. When measuring prostate volume by TRUS, we conducted the measurements two ways at the same time in all patients: by use of height obtained by transaxial scanning and by use of height obtained by midsagittal scanning. Prostate volume was calculated by using the ellipsoid formula ([height×length×width]×π/6).

Results: For prostate volume measured by TRUS, a paired t-test revealed a significant difference between using height obtained by transaxial scanning and that obtained by midsagittal scanning in all patients (28.5±10.1 g vs. 28.7±9.9 g, respectively, p=0.004). However, there were no significant differences in the prevalence of prostate volume more than 20 g (known benign prostatic enlargement [BPE]) between the two methods by chi-square test (90.5% [n=876], 90.8% [n=879], respectively; p=0.876). When analyzed in the same way, there were no significant differences in the prevalence of prostate volume more than 30 g (generally, high-risk BPE) between the two methods (34.5% [n=334], 36.3% [n=351], respectively; p=0.447).

Conclusions: Although prostate volume by TRUS differed according to the method used to measure height, that is, transaxial or midsagittal scanning, we conclude that there are no problems in diagnosing BPE clinically by use of either of the two methods.

Keywords: *Prostate; Prostatic hyperplasia; Ultrasonography*

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INTRODUCTION

Benign prostatic hyperplasia (BPH) is common in middle-aged men, is found in over half of 60-year-old men, and is found in almost all 80-year-old men [1]. Because BPH can lower the quality of life, active diagnosis and treatment are now being conducted. Many urologists routinely use transrectal ultrasonography (TRUS) to diagnose BPH. TRUS is useful in that it can evaluate the size, shape, presence of adenoma, and anatomy of the prostate relatively accurately and noninvasively. Three techniques are used to measure prostate volume: planimetry calculation, prolate ellipse volume calculation, and ellipsoid volume measurement [2]. Among them, prolate ellipse volume calculation is commonly used because it is fast and precise. It is calculated as follows: prolate ellipse volume (cm)=(length×width×height)×π/6. Length refers to the longitudinal diameter of the prostate. It is obtained by calculating the distance from the proximal external sphincter to the urinary bladder. Also, width refers to the transverse diameter of the prostate. It is obtained by calculating the maximal transverse diameter at the midgland level of the prostate [3].

Meanwhile, height refers to the anteroposterior diameter of the prostate. It can be obtained on two planes, axial and sagittal. It remains controversial which method is more accurate for measuring prostate volume. Even in the 9th edition of *Campbell-Walsh Urology*, the textbook of urology, the authors describe in the text that the anteroposterior diameter (height) of the prostate is measured on the axial plane. However, they describe at the same time in the figure legend that it is measured on the sagittal plane [4]. Thus, we aimed to compare the two methods of obtaining the height of prostate to determine which assessment of height is more accurate and useful for diagnosis of BPH.

MATERIALS AND METHODS

A total of 968 patients who underwent TRUS for diagnosis of any diseases related to the prostate from October 2012 to May 2013 were included in this study prospectively. When measuring prostate volume by TRUS, we conducted the measurements two ways at the same time in all patients: by using height obtained by transaxial scanning and by using height obtained by midsagittal scanning (Fig. 1). Prostate volume was calculated by using prolate ellipse volume (cm)=(length×width×height)×π/6. We analyzed the discrepancy of the volume and the prevalence of clinical benign prostatic enlargement (BPE) according to the two methods. TRUS was performed by use of high-resolution (linear 6–16 MHz transducer) units (Aloka Prosound α5; Aloka, Tokyo, Japan) by one skilled urologist. The prostate and seminal vesicle were examined via gray-scale ultrasonography in axial and sagittal planes, and their sizes were determined. Color Doppler examination was also performed to check the blood flow of the prostate. Statistical analysis was conducted by using a paired t-test to determine the difference between the volume measured by the two methods. The chi-square test was used to determine the difference in the prevalence of clinical BPE determined by use of the two methods. The level of statistical significance was set at a $p < 0.05$. All analyses were done by using PASW Statistics ver. 18.0 (SPSS Inc., Chicago, IL, USA).

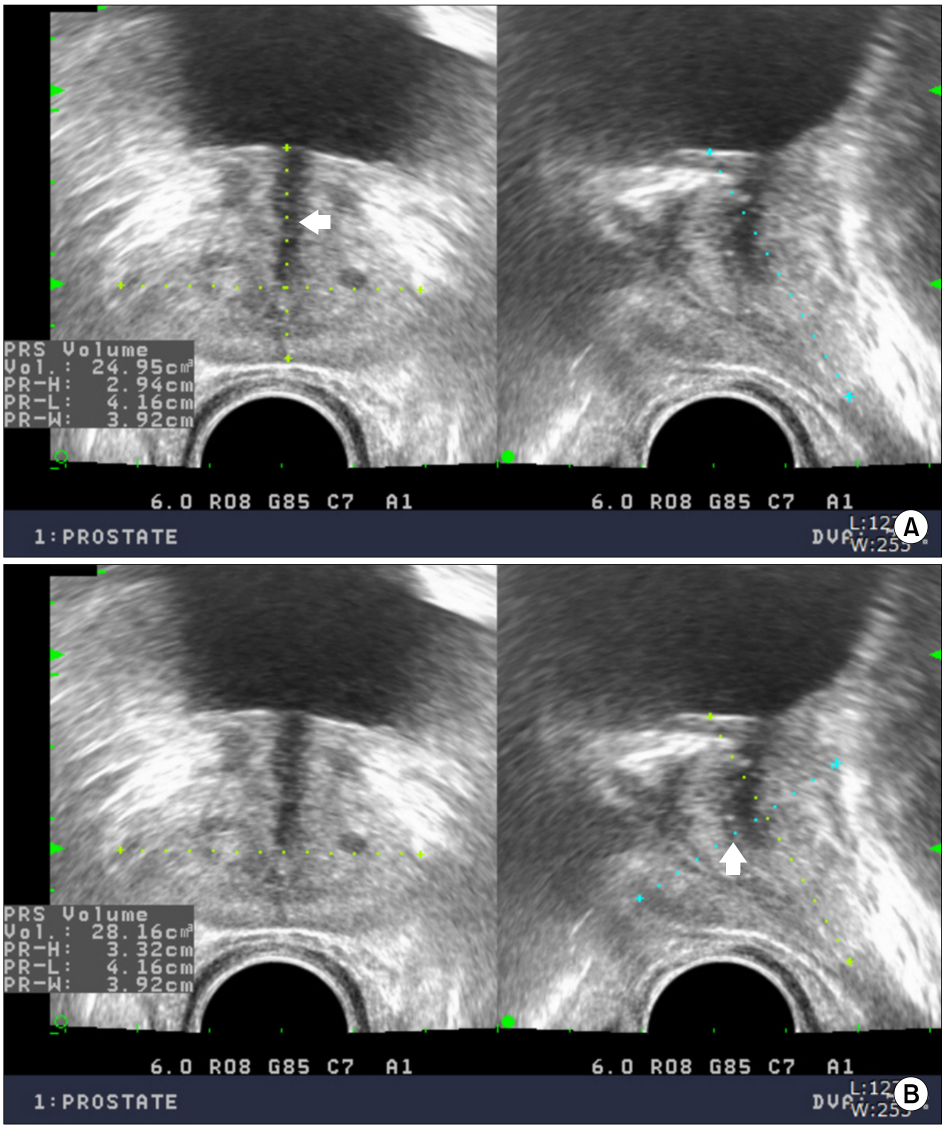

FIG. 1. Measurement of prostate volume by transrectal ultrasonography. (A) Height (arrow) was measured by transaxial scanning (2.94 cm), and prostate volume was calculated as 24.95 mL. (B) Height (arrow) was measured by midsagittal scanning (3.32 cm), and prostate volume was calculated as 28.16 mL.

RESULTS

The mean age of the patients was 58.4 years (range, 21.0–88.0 years). The average prostate volume measured by TRUS by using height determined from the transaxial scans was 28.5±10.1 mL and that measured by using height determined midsagittally was 28.7±9.9 mL. A paired t-test revealed a significant difference between the methods in all patients (p=0.004). When analyzed by age groups in the same way, there was a significant difference in men in their 50s (27.4±6.8 mL vs. 27.9±6.9 mL, n=500), but there were no significant differences in the other age groups (Table 1). There were no significant differences in the prevalence of prostate volume greater than 20 mL (known BPE) between the two methods in all patients by chi-square test (90.5% [n=876] and 90.8% [n=879], p=0.876). When analyzed by age groups, there were also no significant differences in the prevalence of prostate volume more than 20 g (Table 2). Similarly, there were no significant differences in the prevalence of prostate volume more than 30 mL (generally, high-risk BPE) between the two methods (34.5% [n=334] and 36.3% [n=351], p=0.447) in all patients and by age groups (Table 3).

TABLE 1. The mean prostate volumes by the two methods according to age groups

Age group	Transaxial (mL)	Midsagittal (mL)	p-value
All patients (n=968)	28.5±10.1	28.7±9.9	0.004[a]
20s (n=3)	23.0±6.1	22.3±5.5	0.667
30s (n=8)	22.8±6.5	24.5±8.4	0.144
40s (n=111)	24.1±5.1	24.5±5.5	0.109
50s (n=500)	27.4±6.8	27.9±6.9	0.000[a]
60s (n=216)	30.7±11.7	30.8±11.2	0.646
70s (n=115)	32.7±16.4	32.3±16.1	0.105
80s (n=15)	37.0±20.9	36.0±17.8	0.407

Values are presented as mean±standard deviation.
[a]: $p<0.05$, significant.

DISCUSSION

Generally, prostate volume is measured by digital rectal examination, TRUS, computed tomography, magnetic resonance imaging, and in real specimens after prostatectomy [5,6]. Among these methods, TRUS has been the most widely used imaging modality for estimating prostate size because it has been shown to be inexpensive, rapid, reproducible, and well correlated with actual prostate volume. There are several techniques for estimating prostate volume. These days, the prolate ellipse volume ([length×width×height]×π/6) is typically used and has been shown to be rapid, reproducible, highly correlated with actual prostate volume, and easily applied [7]. However, because the prostate is not a true oval, it remains controversial as to how we should measure the height of the prostate. Littrup et al. [3] claimed that the height of the prostate must be obtained on the transaxial plane, which means that height is measured maximally at the midgland level. By contrast, Dahnert [8] reported that the height measurement was corrected by sagittal projection in a plane perpendicular to the length measurement to avoid the salami effect (salami can be sliced in many different ways: to obtain larger slices, some prefer to cut it obliquely).

In our study, the average of prostate volume differed significantly between the two methods of measurement: by using height obtained on transaxial scanning compared with that obtained on midsagittal scanning. However, when analyzed by age group, there were no significant dif-

TABLE 2. Comparison of diagnosis rate of benign prostatic enlargement (≥20 mL) between the two methods by age groups

Age group	Method	Prostate size (mL)		p-value
		<20	≥20	
All patients	Transaxial	92	876	0.876
	Midsagittal	89	879	
20s	Transaxial	1	2	1.000
	Midsagittal	1	2	
30s	Transaxial	4	4	1.000
	Midsagittal	4	4	
40s	Transaxial	23	88	0.734
	Midsagittal	20	91	
50s	Transaxial	39	461	0.905
	Midsagittal	37	463	
60s	Transaxial	14	202	1.000
	Midsagittal	14	202	
70s	Transaxial	8	107	0.633
	Midsagittal	11	104	
80s	Transaxial	3	12	1.000
	Midsagittal	2	13	

TABLE 3. Comparison of diagnosis rate of benign prostatic enlargement (≥30 mL) between the two methods by age groups

Age group	Method	Prostate size (mL)		p-value
		<30	≥30	
All patients	Transaxial	634	334	0.447
	Midsagittal	617	351	
20s	Transaxial	2	1	1.000
	Midsagittal	3	0	
30s	Transaxial	6	2	1.000
	Midsagittal	5	3	
40s	Transaxial	95	16	0.472
	Midsagittal	90	21	
50s	Transaxial	345	155	0.380
	Midsagittal	331	169	
60s	Transaxial	121	95	1.000
	Midsagittal	120	96	
70s	Transaxial	60	55	0.895
	Midsagittal	62	53	
80s	Transaxial	5	10	1.000
	Midsagittal	6	9	

ferences except among men in their 50s. The difference in prostate volume among men in their 50s was about 0.5 mL. However, we do not think that there is an effect by age. We suspect that because the number of patients was small except for the group of men in their 50s, there were no statistically significant differences in prostate volume in the other age groups. Moreover, we do not think the difference will influence medical treatment. We did not determine which is more accurate because we could not compare prostate volume on TRUS with the prostate volume of a real specimen.

Although it is the most widely used formula for TRUS volume determination, reports of the accuracy of the ellipsoid formula are mixed [9-11]. These days, however, most urologists think that prostate volume is underestimated by TRUS in principle. According to the study of Rodriguez Jr et al. [12], the primary factor underlying the inconsistency in volume estimation of prostate weight appears to be the ellipsoid formula, because pathologically determined dimensions still had a 75% error. Independent of gland size, the TRUS correlation underestimated weight 80% of the time by greater than 30% in 55% of patients. Contrary to previous reports, TRUS width and not length is the least reliable factor. Also, Park et al. [2] claimed that the prostate size measured on midsagittal scanning was more accurate compared with real specimen volume. In our study, we calculated prostate volumes by use of the ellipsoid formula on both transaxial and midsagittal scannings. The average of prostate volume by use of height obtained by midsagittal scanning was larger than that by use of height obtained by transaxial scanning. We think that this may be because the prostate is less pressurized on the midsagittal plane by the ultrasound probe.

If we use an ellipsoid formula when estimating prostate volume by TRUS, we can guess that it will be more accurate to obtain the height of the prostate on midsagittal scanning. The important thing, however, when we diagnosis and treat BPH is that it is almost impossible to know the patient's real prostate size. We can determine it by imaging study in most cases; thus, it is important that there are significant differences in prostate size between the above two methods. Because there was a significant difference in our study, we studied whether the difference could influence the diagnosis of BPE.

Prostate enlargement is a common finding among elderly men with BPH [13] and is considered an important risk factor leading to urinary retention [14]. There are many criteria of prostate size for diagnosing BPH. Garraway et al. [15] determined BPH when prostate size was over 20 mL, and Bosch et al. [16] determined BPH when prostate size was over 30 mL. Generally there are many another criteria for diagnosing BPH, such as maximum flow rate, International Prostate Symptom Score (IPSS), and prostate size measured by digital rectal examination, but these days, prostate size is thought to be important for treating BPH patients.

Generally, 5α-reductase inhibitors are used for BPH patients with a prostate volume over 40 mL in Western countries. However, we assume that Asian men may have smaller prostates than do western men. One Korean study claimed that a large prostate should be considered a volume over 35 mL [17]. Furthermore, according to study of Hong et al. [18], the failure rate of medical treatment for BPH patients was higher in men having a prostate volume over 32 mL. Moreover, there are many studies in Western men, also. According to the Olmsted County study [19], the probability of receiving medication or surgery was increased 2.3 times in BPH patients having a prostate volume over 30 mL. Also, Debruyn et al. [20] studied the efficacy and safety of dutasteride on the basis of a prostate volume of 30 mL. Bosch et al. [21] claimed that men with growing prostates are at a greater risk of symptomatic deterioration and that men who have prostates that do not grow significantly are more likely to improve symptomatically.

On the basis of the evidence in these studies, we studied splitting the patients into two groups, those with prostate volume over 20 mL and those with prostate volume over 30 mL. In our study, although there was a significant difference in average prostate volume between the transaxial scanning and midsagittal scanning measurements, the diagnosis rate of BPE (over 20 mL or 30 mL) did not differ between the two methods. We think that this result is meaningful because we can expect that there will be no problem in treating BPH patients no matter which method is used. In a double-blind, placebo-controlled, multicenter, randomized trial comparing the effects of doxazosin, finasteride, and doxazosin plus finasteride for an average of 5 years, combination therapy was the most effective therapy in terms of reduction of the risk of clinical progression [22]. Thus, regarding medical treatment for BPH patients, the accurate estimation of prostate volume is important.

The value of our study is that we measured prostate volume by TRUS by using the height determined by transaxial and midsagittal scanning in a large population. We then analyzed the data according to age groups. Prostate volume measured by TRUS was performed by one skilled urologist and with one set of ultrasonography equipment. Thus, we could reduce technical errors. However, the patients of our study were not prostate cancer patients; thus, it is a limitation of our study that we could not compare prostate volume measured by TRUS with real specimens. We suggest that an excellent study would be to compare prostate volume with real specimens, for example, a cadaver study. Another limitation of our study is that we did not assess the IPSS or lower urinary tract symptoms.

CONCLUSIONS

Although prostate volume by TRUS differed according to the method used to measure height (transaxial or midsagittal scanning), we suspect that prostate volume obtained on midsagittal scanning is more accurate but that there are no problems with diagnosing BPE clinically by use of either of the two methods. However, further study

is needed of the correlation between prostate volume measured by TRUS and that measured by use of real specimens.

CONFLICTS OF INTEREST

The authors have nothing to disclose.

REFERENCES

1. Harding C, Robson W, Drinnan M, Sajeel M, Ramsden P, Griffiths C, et al. Predicting the outcome of prostatectomy using non-invasive bladder pressure and urine flow measurements. Eur Urol 2007;52:186-92.
2. Park SB, Kim JK, Choi SH, Noh HN, Ji EK, Cho KS. Prostate volume measurement by TRUS using heights obtained by transaxial and midsagittal scanning: comparison with specimen volume following radical prostatectomy. Korean J Radiol 2000;1:110-3.
3. Littrup PJ, Williams CR, Egglin TK, Kane RA. Determination of prostate volume with transrectal US for cancer screening. Part II. Accuracy of in vitro and in vivo techniques. Radiology 1991;179:49-53.
4. Ramey JR, Halpern EJ, Gomella LG. Ultrasonography and biopsy of the prostate. In: Wein AJ, Kavoussi LR, Novick AC, Partin AW, Peters CA, editors. Campbell-Walsh urology. 9th ed. Philadelphia: Saunders; 2007. p. 2884-6.
5. al-Rimawi M, Griffiths DJ, Boake RC, Mador DR, Johnson MA. Transrectal ultrasound versus magnetic resonance imaging in the estimation of prostatic volume. Br J Urol 1994;74:596-600.
6. Tewari A, Indudhara R, Shinohara K, Schalow E, Woods M, Lee R, et al. Comparison of transrectal ultrasound prostatic volume estimation with magnetic resonance imaging volume estimation and surgical specimen weight in patients with benign prostatic hyperplasia. J Clin Ultrasound 1996;24:169-74.
7. Jeong CW, Park HK, Hong SK, Byun SS, Lee HJ, Lee SE. Comparison of prostate volume measured by transrectal ultrasonography and MRI with the actual prostate volume measured after radical prostatectomy. Urol Int 2008;81:179-85.
8. Dahnert WF. Determination of prostate volume with transrectal US for cancer screening. Radiology 1992;183:625-6.
9. Terris MK, Stamey TA. Determination of prostate volume by transrectal ultrasound. J Urol 1991;145:984-7.
10. Loeb S, Han M, Roehl KA, Antenor JA, Catalona WJ. Accuracy of prostate weight estimation by digital rectal examination versus transrectal ultrasonography. J Urol 2005;173:63-5.
11. Nathan MS, Seenivasagam K, Mei Q, Wickham JE, Miller RA. Transrectal ultrasonography: why are estimates of prostate volume and dimension so inaccurate? Br J Urol 1996;77:401-7.
12. Rodriguez E Jr, Skarecky D, Narula N, Ahlering TE. Prostate volume estimation using the ellipsoid formula consistently underestimates actual gland size. J Urol 2008;179:501-3.
13. Arrighi HM, Metter EJ, Guess HA, Fozzard JL. Natural history of benign prostatic hyperplasia and risk of prostatectomy. The Baltimore Longitudinal Study of Aging. Urology 1991;38(1 Suppl):4-8.
14. Jacobsen SJ, Jacobson DJ, Girman CJ, Roberts RO, Rhodes T, Guess HA, et al. Natural history of prostatism: risk factors for acute urinary retention. J Urol 1997;158:481-7.
15. Garraway WM, Collins GN, Lee RJ. High prevalence of benign prostatic hypertrophy in the community. Lancet 1991;338:469-71.
16. Bosch JL, Kranse R, van Mastrigt R, Schroder FH. Reasons for the weak correlation between prostate volume and urethral resistance parameters in patients with prostatism. J Urol 1995;153(3 Pt 1):689-93.
17. Cho JS, Kim CI, Seong DH, Kim HS, Kim YS, Kim SJ, et al. Cut-off point of large prostate volume for the patients with benign prostatic hyperplasia. Korean J Urol 2005;46:1246-50.
18. Hong SJ, Ko WJ, Kim SI, Chung BH. Identification of baseline clinical factors which predict medical treatment failure of benign prostatic hyperplasia: an observational cohort study. Eur Urol 2003;44:94-9.
19. Jacobsen SJ, Jacobson DJ, Girman CJ, Roberts RO, Rhodes T, Guess HA, et al. Treatment for benign prostatic hyperplasia among community dwelling men: the Olmsted County study of urinary symptoms and health status. J Urol 1999;162:1301-6.
20. Debruyne F, Barkin J, van Erps P, Reis M, Tammela TL, Roehrborn C, et al. Efficacy and safety of long-term treatment with the dual 5 alpha-reductase inhibitor dutasteride in men with symptomatic benign prostatic hyperplasia. Eur Urol 2004;46:488-94.
21. Bosch JL, Bangma CH, Groeneveld FP, Bohnen AM. The long-term relationship between a real change in prostate volume and a significant change in lower urinary tract symptom severity in population-based men: the Krimpen study. Eur Urol 2008;53:819-25.
22. McConnell JD. The long term effects of medical therapy on the progression of BPH: results from the MTOPS trial [abstract]. J Urol 2002;167:1042.